Engineered Fiber Based Lost Circulation Pill to Abridge Lost Circulation of Geothermal Well

(Rekayasa Tablet LCM Berbahan Serat Untuk Menanggulangi Masalah Hilang Lumpur Pada Sumur Panas Bumi)

Apriyansah Toni, Astra Agus Pramana, Bambang Kustono

Master Program of Petroleum Engineering, Universitas Trisakti, Jakarta11440

Abstract

Loss circulation is a major problem and known as the biggest challenge during drilling and well construction.This can leadsto various consequences,such as stuck pipe, loss of material and time to combat the losses, and even losing the well itself. Severe loss circulation conditions are often met while drilling geothermal wells in Indonesia. Partial to total losses have start experienced since drilling the surface section. Cement plugs is one of the conventional methods to cure losses. Number of cement plugs differ from one well to another well. Even in some wells, number of cement plugs performed for loss circulation plug can be over 30 times with total of more than 4,000 barrels of cement slurry pumped. Solution other than basic loss circulation material and cement plug must be developed to optimize curing loss time. Engineered fiber base concentration which is include; Base Fluid, LCM and Solid Package was obtained from simulation, then trial and error in laboratory was conducted. Based on the final recipe, the control pill was able to hold pressure and not leaking, even when using 5 mm grid clearance. Additional combined stiff fiber and flexible fiber with concentration of 6 lbs/bbl sufficient to hold exessive loss circulation.

Keywords: fractures,geothermal, LCM

Sari

Kehilangan sirkulasi lumpur adalah masalah utama dan dikenal sebagai tantangan terbesar selama pengeboran dan konstruksi sumur. Hal ini dapat menyebabkan berbagai konsekuensi, seperti pipa terjepit, kehilangan material dan waktu untuk mengatasi kehilangan, dan bahkan kehilangan sumur itu sendiri. Kondisi kehilangan sirkulasi yang parah sering dijumpai saat pengeboran sumur panasbumi di Indonesia. Kehilangan lumpur sebagian hingga total dapat dialami sejak pengeboran bagian permukaan. Penyumbat semen adalah salah satu metode konvensional untuk mengatasi kehilangan. Jumlah sumbat semen berbeda antara satu sumur dengan sumur lainnya. Bahkan di beberapa sumur, jumlah penyumbatan semen yang dilakukan bisa lebih dari 30 kali dengan jumlah lebih dari 4.000 barel semen dipompakan. Solusi selain bahan material dasar untuk mengatasi kehilangan sirkulasi dan penyumbat semen harus dikembangkan untuk mengoptimalkan waktu curing loss. Konsentrasi bahan dasar serat yang direkayasa meliputi; fluida dasar, LCM dan Solid Package diperoleh dari simulasi, kemudianpercobaan trial and error di laboratorium dilakukan. Berdasarkan resep akhir, pil pengontrol ini mampu menahan tekanan dan tidak bocor, meski saat menggunakan grid clearance 5 mm. Serat kaku yang dikombinasikan dengan serat fleksibel dengan konsentrasi 6 lbs / bbl cukup untuk menahan kehilangan sirkulasi yang berlebihan.

Kata-kata kunci: rekahan, panasbumi, LCM

*Bambang Kustono (*corresponding author*):
E-mail: b.kustono13@gmail.com
Tel: +62-81315587069

I. INTRODUCTION

Usually the type of formation in geothermal is fault, natural fractures or fissures that has high permeability. The natural fractures in formation are represented in below. When drilling the open hole section, fluid pressure applied to the formation higher than formation pressure will cause a loss of circulation when these fractures are intersected. The nature of fractures varies from fissures to big fractures and in extreme cases to vugular resulting in partial to total losses.

In the past it has been the best practice to spot lost circulation material down hole at different time intervals with no regards for spotting an effective loss circulation materials.

Geothermal operators should determine a system that has ability blanketing and plugging fractures zones. Based on recent case histories a fiber system has been developed to cure lost circulation caused by the presence of natural fractures. Engineered fibers

system focuses more on physics rather than chemistry and depends on characterization and distribution of solids in combination with dual fibers technology to address lost circulation challenges of geothermal wells.

II. METHOD

The best practice to handle geothermal lost circulation can be shown on Figure 1 below. Specific data from wellsite is required to do simulation in lost circulation software, such as loss rate, formation type, and any historical data. With this information, the software can calculate concentration for components of Engineered Fiber Base Lost Circulation Material Control Pill.

Material for lost circulation material pill includes three main components, which are viscosifier for base fluid, Lost Circulation Material (LCM) system, and solid package blend. LCM system is a blend of two type of fibers. Namely thin, flexible fibers and stiff fibers, which will be combined to reduce permeability of thief zone and maximize plugging efficiency.

For an effective treatment not only the proper combination of fibers is needed, also an optimized package of solids is necessary to reduce the permeability of the plug system.

The correct classification of the solids should be done to get the proper particle size distribution (PSD) of each particle in the system, for a proper computation of the minimum percentage of solids fraction distribution (SFV). Below this percentage, the robustness and effectiveness of the fibers will startto deteriorate, and also the resistancefor differential pressure will decrease. The maximum limit for the SVF should be determined by the lab test and the restrictions on the equipment being used and BHA.

Several tests were performed using the fibers and the package of solids with the different concentrations of fine, medium and coarse granules. The result of those tests generated a graphical diagram with the better ratios between the granules, classifying zones with better results. The results from the tests generate a database for loss circulation software (LCS), createdto evaluate the losses and design the pills.

The LCS will recommend the system to be used, based on the basic information already given. The SVF can be provided by the user or the LCS can use the minimum recommended the type of granules are available from the LCS database to be chosen by the user or it can be input in the software based on the solids available on the field/base to the design solid package, always considering the criteria of the PSD of the granules. The base fluid is a water-based viscosifier.

The next step is running the calculations and the LCS willprovide a recipe for the pill base on the data provided. The recipe will have the final density of the pill, the SVF, concentration of the fibers and the concentrations of each granule. There is an option for the user to change the concentration of the solids, due local inventory restrictions for example, and the system will give the “performance index” that shows how effective the package of solids will be on reducing the permeability of the plug and as a consequence curing the losses. The green zone the most effective followed by the orange zone that is less effective and by the red zone with high permeability and very low effectiveness.

III. RESULTS AND DISCUSSION

Laboratory testing for engineered fiber base LCM control pill was done by collecting samples for base fluid from Mud Company. There have to be fine size particles, medium size particles, and coarse size particles to be mixed with viscosifier in base fluid. Rheology is tested for base fluid at surface condition and after conditioning at downhole temperature to make sure there are no significant changes downgrading fluid properties. Decision tree for laboratory testing is shown in Figure 2.

To be able to know particle composition range, particle size of each solid particle must be tested using sieve analysis, which called gradation test. Calcium Carbonate ($CaCO_3$) from a Mud Company was run through several sieves with different mesh diameter to know diameter of calcium carbonate. Calcium carbonate sample is weighted for 100 gram sand put on the top of multiple sieves. For testing, there are seven mesh sizes lined up to calculate biggest particle diameter size.

Using this method, particle diameter sizes are known. Diameter of coarse, medium, and fine $CaCO_3$ from Mud Company is 0.0158 inch; 0.0075 inch; 0.0019 inch. The utilization for the apparatus is to select the desired sizes of the material for the test. Aside from calcium carbonate in base fluid, there is silica flour for additional solid in the system and viscosifier to improve rheology of the base fluid. Base fluid must have good consistency to be able to hold fibers.

The next step is to input material data and well information to lost circulation simulator. Some information needed is loss zone location and loss mechanism. Loss zone location needs to be identified based on available well data. It is normally inputted as on bottom or off bottom. On bottom can be defined when lost circulation occurs while drilling ahead or lost is due to natural fractures, caverns, vugs or high permeable formation. Lost circulation is considered off bottom if the loss occurs while tripping or increasing mud weight or from killing the well.

Aside from inputting lost circulation location, the simulation needs other information for loss zone data, BHA configuration to do the treatment, and finally recommendation of pill and additive combinations, within the analysis of each simulation. Some data was needed for loss zone data, such as loss mechanism, mud loss occurrence, recommended mechanism, severity, loss zone info, wellbore info, and drilling fluid type.

In the case of the geothermal well for the simulation, the loss mechanism is considered as fractures, and mud loss event is usually in surface sections, up to 520 meters, which is not a reservoir zone. The severity is high as loss rate is above 600 bbl/hr. temperature maximum for 60 ^{o}C with usage of water base mud (water density). Treatment will be pumped to the well using Open Ended Drill Pipe (OE DP). Control Pill Concentration Data are given in Table 1. Once all the data is inputted, then simulator will show recommended system, which showed that engineered fiber base lost circulation material control pill will be the most suitable solution for common geothermal wells drilling lost circulation issue.

Compared to the performance as well shown below is the price per unit for each designed that has been acknowledge to be effective for each measurement. Engineered Fiber LCM Pill Cost per Size Design is shown in Figure 3.

II. CONCLUSIONS

Conclusion that can be drawn from the analysis that had been conducted is as follow:

1. This research had found best combination of base fluid, LCM concentration, and solid packages for Engineered Fiber Base LCM Pill that pass the plugging efficiency test for different type of fractures width (FW). The result is the SVF 32.90%, density 1557.74 Kg/m^3, CaCO3 M 667.12 Kg/m^3, silica flour 122.22 Kg/m^3, CaCO3 C 97.98 Kg/m^3, and LCM fiber 7.7 Kg/m^3.
2. Engineered fibers treatment system can be optimized to control losses in natural fractures of loss zone up to 5 mm. Moreover it also can be used in smaller width fractures, as well shown to be economic reasonable as the ultimate solution for each cases.
3. The succeed of the engineered fiber based lost circulation material is determined not only by percentage of composition but also by the material selection, as well the material grading. Diameter of coarse, medium, and fine CaCO3 from Mud Company is 0.0158 inch; 0.0075 inch and 0.0019 inch.
4. Fiber based LCM is proven by laboratory test to be an alternative of loss handling in geothermal drilling operation at upper zones as spaces prior cement plug job or as direct loss cure.
5. The main factor in designing engineered fiber lost circulation pill is concentration of solid package (CaCO3 M and CaCO3C).

REFERENCES

1. Alexandre Victor de Andrade, Lenin Omar Diaz, Raul Bermudez, Henry Daniel Bedino, Nixklafe Neil Atencio Carrilo, Candelario Delago Vargas, Angel Pedro Carrilo, Ignacio Ramirez Martinez, “Fiber Technology Simply and Effectively Cure Total Losses in Southern Mexico Without Knowing Size of Fractures”, SPE 150844, Presented at SPE Latin American and Caribbean Petroleum Engineering Conference in Mexico 16-18 April, 2012.
2. Arshad, U., Jain, B., et.al., “Engineered Fiber-Based Loss Circulation Control Pills To Successfully Combat Severe Loss Circulation During Drilling and Casing Cementing in Northern Pakistan“, SPE 169343, Presented in SPE Conference in Macarabo, Venezuela, 21-23 May 2014.
3. Clapper, D.K., Szabo, J.J., Spence, S. et al. 2011. One Sack Rapid Mix and Pump Solution to Severe Lost Circulation,” Paper SPE/IADC 139817, presented at the SPE/IADC Drilling Conference and Exhibition, San Diego, California, 6-8 March 2012.
4. Datwani, Alli., “Review Of Lost Circulation Mechanisms With The Focus On Loss To Natural And Drilling Induced Fractures”, July 2012.
5. Finger, J., Blakenship, D., Handbook of Best Practices for Geothermal Drilling. Sandia, National Laboratories Albuquerque, New Mexico. USA, 2010.
6. Goodman, A. Malcolm, Lost Circulation Experience in GeothermalWells. International Geothermal Drilling and CompletionsTechnology Conference, Albuquerque, NM,USA, 21 January 1981.
7. Ivan, C., Bruton, J. andBloys, B., Lost Circulation Can be Managed Better than Ever. World Oil, June 2003.
8. Nelson, E.B. and Guillot, D. 2006. Well Cementing, Second Edition.Schlumberger.
9. Pilehvari, A.A. and Nyshadham, V.R. 2002. Effect of Material Type and Size Distribution on Performance of Loss / Seepage Control Material. SPE 73791, presented at International Symposium and Exhibition on Formation Damage Control, Lafayette, Lousiana 20-21 February 2002.
10. Sanders, M.W., Young, S., and Friedheim, JE. 2008. Development and Testing of Novel Additives forImproved Wellbore Stability and Reduced Losses. Paper AADE-08-DF-HO-19 presented at AADE Fluids Conference and Exhibition, Houston Texas 8-9 April 2008.
11. Slaheddine Kefi, Jesse C.Lee, Nikhil Dilip Shindgikar, Chrystel Brunet-Campbus, Benoit Vidick, Nelson Ivan Diaz, “Optimizing in Four Steps Composite Lost-Circulation Pills Without Knowing Loss Zone Width”. SPE 133735, Presented at IADC/SPE Asia, Pacific Drilling Technology Conference and Exhibition in Ho Chi Minh City,Vietnam, 1-3 November, 2010.
12. Sveinbjornsson, B.M., Thorhallsson, S. 2013, Driling Performance and Productivity of

Geothermal Well, Presented at 47th US Rock Mechanics/Geomechanics Symposium held in San Fransisco, CA, USA, 23-26 June 2013.

13. Victor de Andrade, Alexandre; Diaz, Lenin Omar; Bermudez, Raul; Bedino, Henry Daniel; Carillo, Nixklafe Neil Atencio; etc. 2012. SPE 150844, "Fiber Technology Simply and Effectively Cure Total Losses in Southern Mexico without Knowing Size of Fractures" Presented at SPE Latin American and Caribbean Petroleum Engineering Conference in Mexico 16-18 April2012.
14. Vidick, B., Yearwood, J.A., and Perthuis, H., How to Solve Lost Circulation Problems. SPE 17811, presented in International Meeting on Petroleum Engineering in Tianjin, China 1-4 November 1988.
15. PertaminaGeothermal Energy: Final Well Report HLS-E/1. Jakarta, Indonesia Maret2016

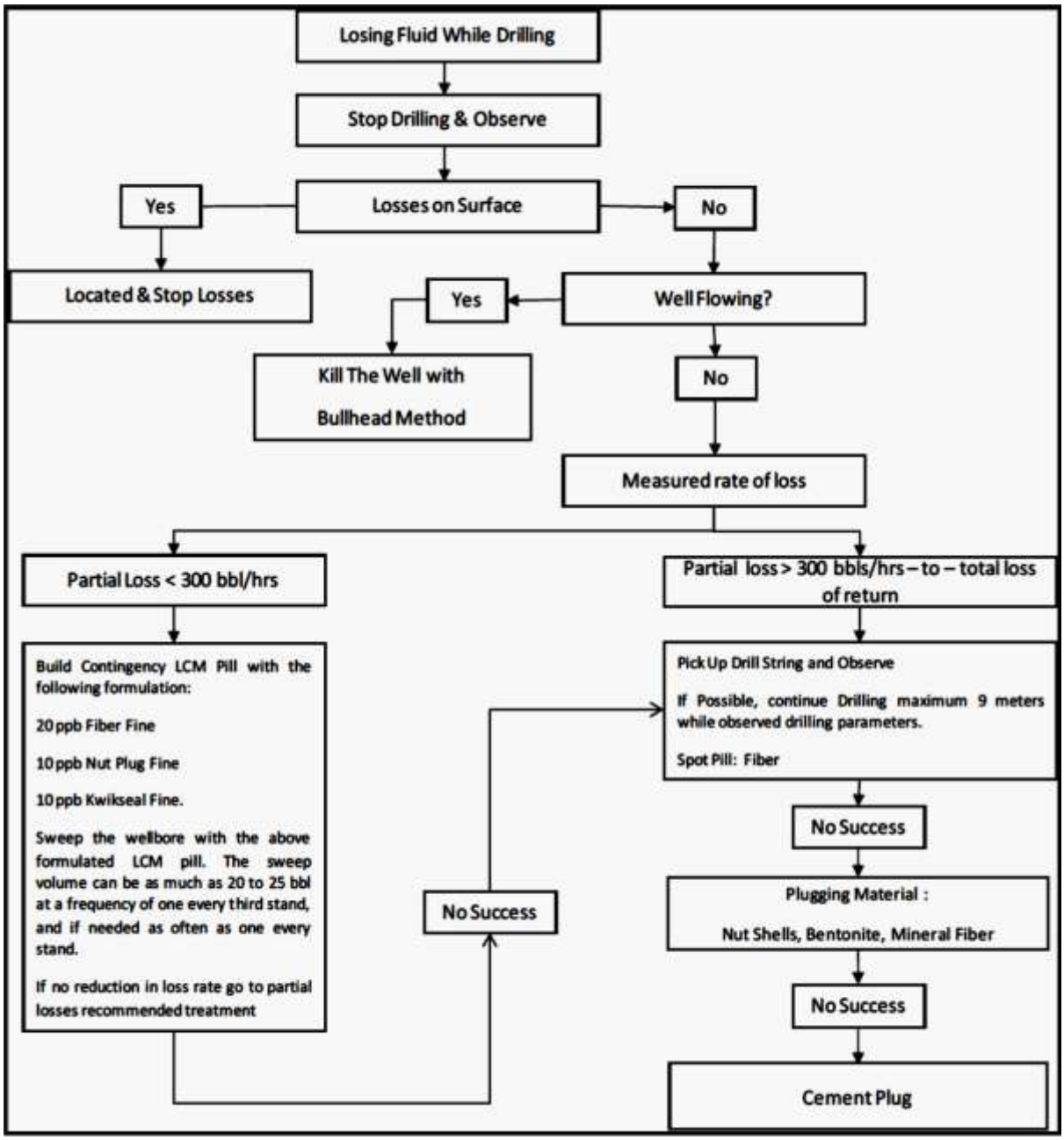

Figure 1. Flowchart Actual Fluid Loss Mitigation Decision Tree

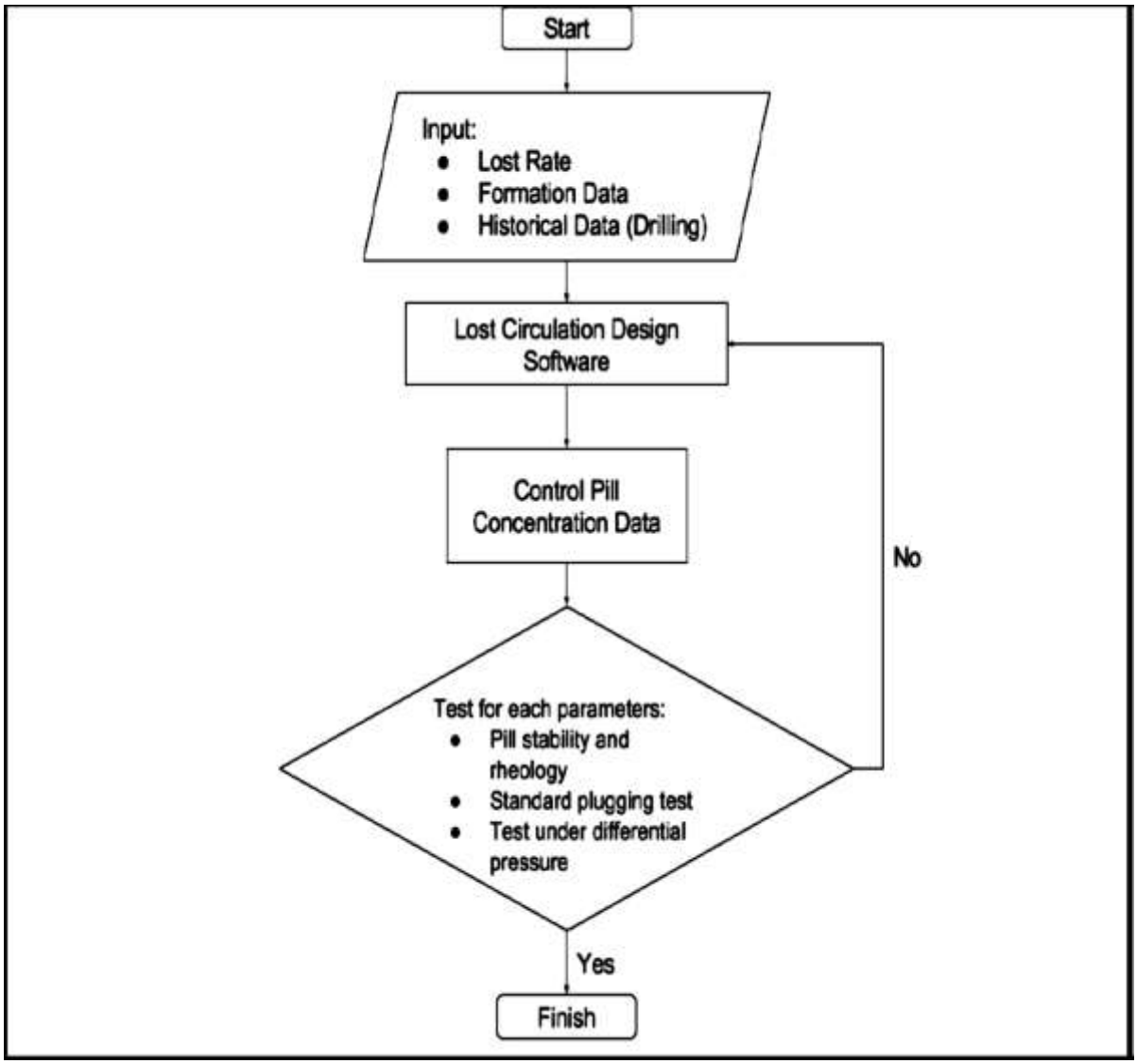

Figure 2. Decision Tree for LaboratoryTesting

Table 1. Control Pill Concentration Data

Composition	Mass, gr				
	1mm	2mm	3mm	4mm	5mm
Silica Flour	221.83	110.23	62.82	89.13	73.33
CaCo3 M	247.55	395.75	458.71	379.26	400.27
CaCo3 C	64.58	26.74	10.67	64.1	58.71
Base Fluid	397.95	397.95	397.95	397.95	397.95
Losseal W	4.62	4.62	4.62	4.62	4.62

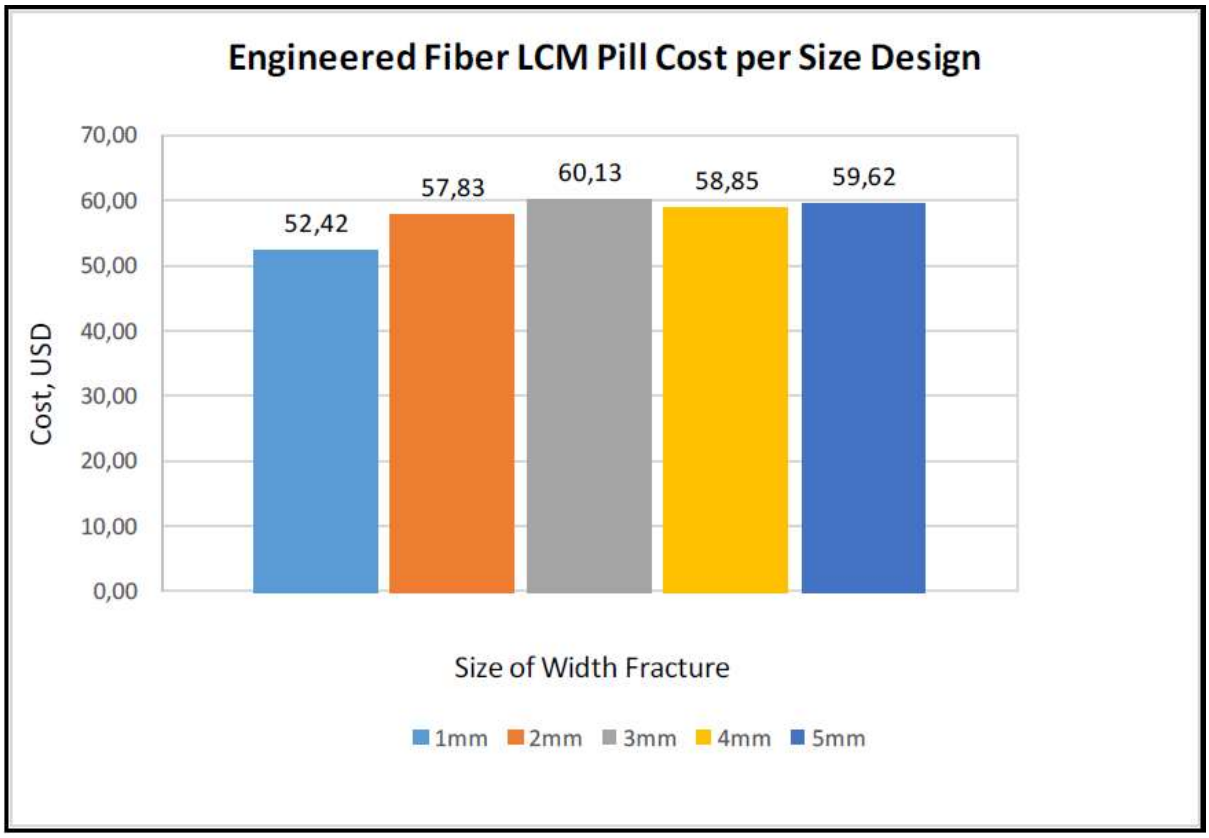

Figure 3. Engineered Fiber LCM Pill Cost per Size Design